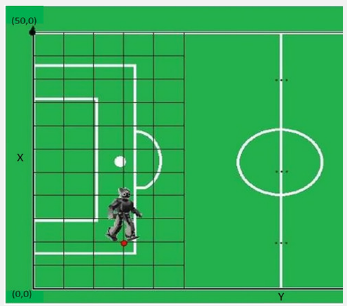
Localization | Research Purpose

Research Introduction

- Robots need autonomous decision-making for self-driving, requiring **robot localization**.
- Only using kinematic inputs aren't reliable due to significant errors like grass texture and robot joint backlash.
- Incorrect position estimates can lead to major mistakes, such as scoring own goals.


RoboCup 2019



Localization

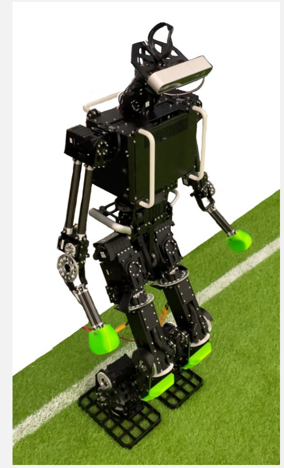
- Aims for an precise and **accurate localization** despite unstable walking and limited-view cameras.

Research Goal

- Develop an algorithm for **real-time position estimation** of the robot.
- Enable **re-estimation of position** after events like the robot falling or "kidnapping" due to collisions between robots.

Humanoid Robot Model


ALICE in Webots


ALICE ver.3

OS : Ubuntu 20.04
HW : Jetson Xavier, Intel NUC
Language : Python, C/C++
Middleware : ROS

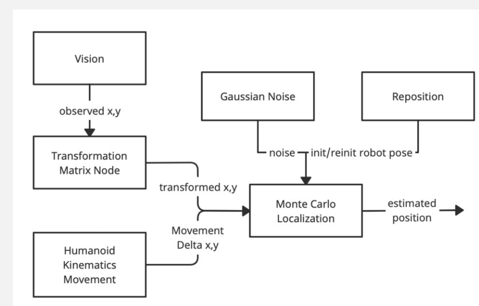
Pseudo-code and System Diagram of Localization

Algorithm 1 Augmented Monte Carlo Localization

Input: χ_{t-1}, u_t, z_t, m
Output: χ_t

static $\omega_{slow}, \omega_{fast}$
$\bar{\chi}_t = \chi_t = \emptyset$
for $m = 1$ to M **do**
  $x_t^{[m]} = \text{sample\_motion\_model}(u_t, x_{t-1}^{[m]})$
  $\omega_t^{[m]} = \text{measurement\_model}(z_t, x_t^{[m]}, m)$
  $\bar{\chi}_t = \bar{\chi}_t + \langle x_t^{[m]}, \omega_t^{[m]} \rangle$
  $\omega_{avg} = \omega_{avg} + \frac{1}{M}\omega_t^{[m]}$
end for
$\omega_{slow} = \omega_{avg} + \alpha_{slow}(\omega_{avg} - \omega_{slow})$
$\omega_{fast} = \omega_{avg} + \alpha_{fast}(\omega_{avg} - \omega_{fast})$
for $i = 1$ to M **do**
  idx = resampling(ω)
  if $max(0.0, 1.0 - \omega_{fast}/\omega_{slow})$ **then**
    add random pose to χ_t
  else
    idx = resampling(ω)
    add $x_t^{[idx]}$ to χ_t
  end if
end for
return χ_t

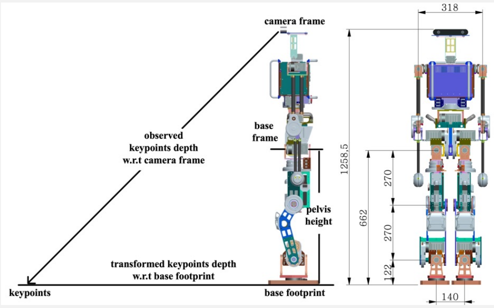
Pseudo-code



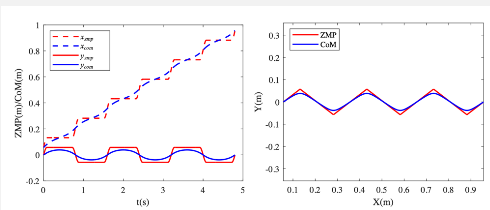
Localization System Diagram

Localization | aMCL-based localization w/ using Object Detection Model

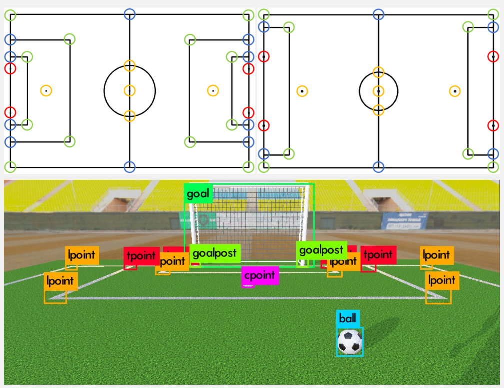
Humanoid Localization Process



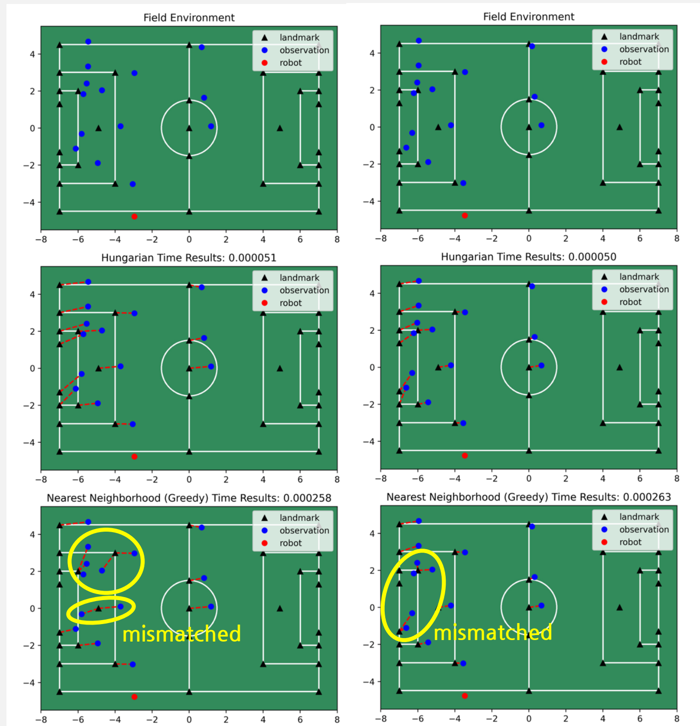
Humanoid “ALICE3”, hardware and TF configuration



(1) Preview Control-based Pelvis and ZMP trajectory



(2) Detection result of pre-defined landmarks



(3) Comparison result of data association method
(Hungarian algorithm and nearest neighbor method)

index	Success Rate (nearest)	Success Rate (hungarian)
scene 1	80.89%	**90.00%**
scene 2	84.25%	**92.01%**
scene 3	83.98%	**93.22%**
scene 4	85.90%	**96.85%**

Data Association evaluation of each methods

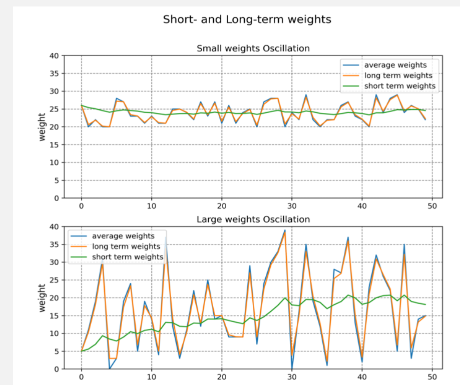
Algorithm 3: Proposed Roulette Wheel Resampling Algorithm

```
Algorithm Resampling (ω);
  Input : Set of weights for each particle ω
  Output: Set of resampled weights for each particle ω_sampled
ω_sampled = ∅
idx = integer number of rand() * M
β = 0.0
ω_max = max(ω)
for i ← 0 to M do
    β = β + rand() * 2.0 * ω_max
    while β > ω^idx do
        β = β − ω^idx
        idx = (idx + 1) % M
    end
    add ω^idx to ω_sampled
end
return ω_sampled
```

$$\omega(x) = \prod_{k=1}^{K} \omega(x)$$

(4) 파티클 가중치 계산

(5) Pseudocode of Roulette Wheel Resampling



(6) Weigh tracking results

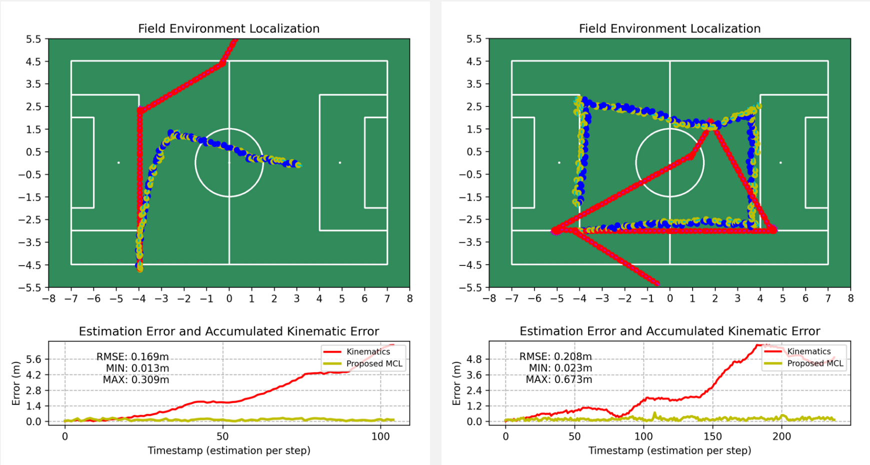
1) Constructing a **motion model** for prediction (ZMP trajectory)
2) Creating a **sensor model** for estimation (Deep learning-based object detection)
3) **Data assignment** between keypoints and landmarks (Hungarian method)
4) Particle sample **weights calculation** (Multi-variant Gaussian function)
5) **Resampling** for the next prediction (Roulette Wheel)
6) **Tracking short- and long-term weights** to address the Kidnap problem

Localization | Results and Performance Evaluation

Simulation Results

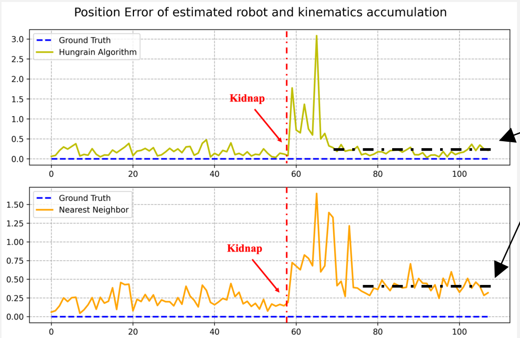
- Precise position estimation in noisy environments like soccer fields.
- Application of Hungarian method and deep learning-based object detection for real-time use.

Ground Truth Estimated position Kinematics position (error)



The localization results from two tested scenarios in a simulated environment

- **Addressing "kidnap" problem**



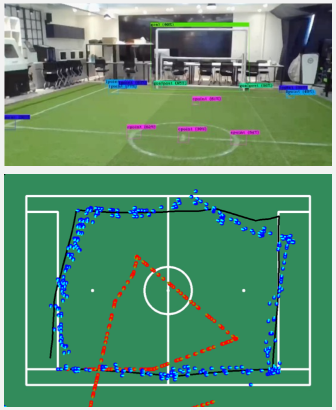
Converging after kidnap

Re-localization of kidnap problem,
Comparison between Hungarian and NN

Real-Word Experiments

Ground Truth Estimated position

Real-World localization in fully autonomous robot plays Soccer



Detection & Localization Result

RoboCup 2022 Bangkok Humanoid AdultSize Competition

RoboCup 2022 Bangkok

RoboCup Bangkok Thailand 2022
RoboCup

CERTIFICATE OF AWARD

RoboCup Humanoid League
AdultSize Soccer Competition
Second Place

HERoEHS
Hanyang University

Jackrit Suthakorn
General Chair of RoboCup 2022

Peter Stone
President of RoboCup Federation

Organized by: Supported by: Local Sponsors by: Global Sponsors by: Event Sponsor by:

RoboCup AdultSize 2nd Place

홈 > 뉴스 > 종합

한양대 로봇축구팀, 국제로봇축구대회 ‘로보컵’ 서 준우승

16일 최종 결승전서 전년도 우승 팀 독일 '님브로'에 7대 1로 패배

승인 2022.07.16 14:11:50

▲대회가 끝나고 한양대 한재권 교수가 이끄는 히어로즈팀이 기념 촬영을 하고 있다. 사진 맨 왼쪽이 한재권 교수, 오른쪽 끝이 팀 리더인 엄윤설 박사

Selected news article